



Biofilm Based Wound Care

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BIOFILM BASED WOUND CARE

When bacteria attach to the surface of the wound and evade the host's defenses, they can quickly develop into a film, which covers the surface. This film, biofilm, is truly a multicellular organism with several well recognized defenses, synergies between different types of bacteria and the ability to reconstitute itself very quickly. The bacteria in the biofilm arrangement are quite different than those in the planktonic form with only 30% of the proteins in the outer membrane being homologous between the two. These phenotype differences along with metabolic differences in the different regions of the biofilm make biofilm very difficult, if not impossible, to eradicate. The best that can be hoped for is suppression of the biofilm to allow for host healing.

The Southwest Regional Wound Care Center along with the Center for Biofilm Engineering were the primary investigators in a study that used electron microscopy to look at the surface of chronic wounds. The study showed that roughly 70% of chronic wounds demonstrated mature biofilm whereas less than 10% of acute wounds demonstrated biofilm. But this study does not reveal if the biofilm plays any role in the nonhealing of wounds. To answer the question whether biofilm contributes to nonhealing of wounds a biofilm based approach to the management of wounds was undertaken. If targeting the biofilm on wounds resulted in wounds healing more quickly and more completely then this would provide good indirect evidence that biofilm does play some role in nonhealing of wounds.

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Theoretically, biofilm is an excellent explanation for the chronic inflammatory state of chronic wounds. Mammalian immune systems are fairly ineffective against mature biofilm. Yet WBC seem to act very aggressively against biofilm. An ineffective white blood cell response to mature biofilm would explain high levels of proinflammatory cytokines, high levels of matrix metalloproteases and because the wound bed is coated with the physical barrier of biofilm, low lev-

els of tissue inhibitors and halo proteases would be expected. The toxins associated with biofilm behavior could explain the progressive necrosis seen in wounds. Wounds do respond partially to antibiotic treatment, but only partially and reemerge quickly once antibiotics are stopped. This ineffectiveness of antibiotics is also seen in other biofilm based diseases, resulting in an indolent course. This indolent course seen in chronic wounds is also seen in the 80% of chronic human infections that, according to the NIH, are biofilm based (such as osteomyelitis, endocarditis, prostatitis, otitis media, sinusitis, dental disease and others).

Through trial and error, laboratory and clinical studies multiple tools have been developed to treat wound biofilm. In treating wounds as if biofilm is a major barrier to wound healing, it is important that the treatments suppress biofilm but not damage host defenses and/or host healing mechanisms. Also since biofilm is so resilient and robust, it has become apparent that multiple concurrent strategies are most effective.

Wounds versus other biofilm based human infections are unique in that the surface of biofilm is accessible, which allows physical management. Tissue surfaces, which touch each other sequester the biofilm and give it the advantage.

Therefore by altering the anatomy, that is opening all undermining, opening all tunneling, sculpting the wound bed to remove crevices and redundant tissue takes the advantage from the biofilm and gives it to the host.

Multiple studies have shown that frequent debridement of the surface of a wound accelerates healing. Tools can be as simple as a curette or as high tech as ultrasonic debridement where the ultrasound energy cavitates and destroys the biofilm structure as well as individual bacteria.

Although systemic antibiotics are fairly ineffective in eradicating biofilm they are a solid tool in

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suppressing the environmental edge of biofilm. Antibiotics prevent seeding of planktonic bacteria back into the wound as well as directly killing the more metabolically active biofilm bacteria in the outer edge. Antibiotics which have unique properties, which allow them to kill metabolically inactive biofilm based bacteria, are preferred. The doses of systemic antibiotics used for wounds should be patterned after other biofilm based diseases such as osteomyelitis, endocarditis, etc., where antibiotics are used at higher doses for longer periods of time.

Topically antimicrobial agents such as antibiotics, silver, cadexomer iodine, and Methylin Blue play a role in directly suppressing biofilm as well as preventing fouling of the dressings through planktonic seeding or detachment fragment adhesion.

Avoiding dressings that promote biofilm growth is very important. Gauze has been found to harbor mature biofilm within six hours of being placed on a nonhealing chronic wound. Therefore dressings with less complex surfaces than cotton such as Alginates, micro fibers, polyurethane foam and a host of other materials have a clear benefit over gauze.

Nonspecific chemicals such as alcohol, Dakin's solution, acetic acid, peroxide, ionic iodine solutions and many other biocides do not penetrate biofilms well. Their use in chronic wounds results in only minimal transient damage to the biofilm while causing extensive damage to host defenses and host healing mechanism. Their use should be avoided. It is important to choose treatments which augment host defenses and host healing for their positive effects on the wound.

Bacteriophage is ubiquitous and is very successful against the most common form of bacteria in nature, which is biofilm. One of the advantages conferred to the bacteria by forming into a biofilm is resistance to viruses. Bacteria phages have adapted right along with the bacteria. This makes bacteria phage a potent enemy of bacteria and therefore our allies. Bacteria phage is ubiquitous, extensively studied in tens of thousands of patients and poses no risks to mammals.

Biofilms are formed by planktonic bacteria through a mechanism called quorum sensing where

Also in a biofilm based approach to wound healing, no grafting or placement of bioengineered skin replacements should be placed on the wound until the biofilm is adequately suppressed and the above measures should be used in concert with the graft to prevent biofilm using the graft material as a food source.

Introduction:

Often we are shown the best two to three cases, some several years old, to illustrate the effectiveness of a particular treatment. Using the principles below, we at the Southwest Regional Wound Care Center have seen significant improvements in wound healing trajectories and number of patients healed. This has produced literally hundreds of cases over the last year for us to choose from to demonstrate the effectiveness of a biofilm based wound care approach. The cases we present here have been selected to demonstrate certain teaching points. Through a biofilm based approach to wound care the vast majority of wounds are expected to heal quickly and completely.

CASE HISTORY:

NAME: J.M.
ACCT: 6105

The patient is a very pleasant 47-year-old white male with longstanding insulin dependent diabetes mellitus. This patient worked as an LVN for years and is no longer able to work. He has no benefits or insurance. He is losing his eyesight. He has had a previous right below knee amputation and presented in March of 2004 with a severe diabetic foot ulcer of the left plantar foot. The patient's course was prolonged, but he eventually healed the wound completely by August of 2004. In February, the patient presented with a new wound in the same area. He was concerned that the previous wound would cause extensive scarring and poor circulation, which would not allow the wound to heal. In fact, his new wound healed quickly despite fairly low oxygenation and multiple organisms cultured from the wound including *Group D Enterococcus*, *Klebsiella*, *Coag Neg. Staph*, methicillin resistant *Xanthomonas* and *Enterobacter*.

Teaching Point: The durability of diabetic feet post wound healing is very good. This patient had recurrence about six months later, which is unusual. However, this did not seem to affect subsequent wound healing of the second wound.



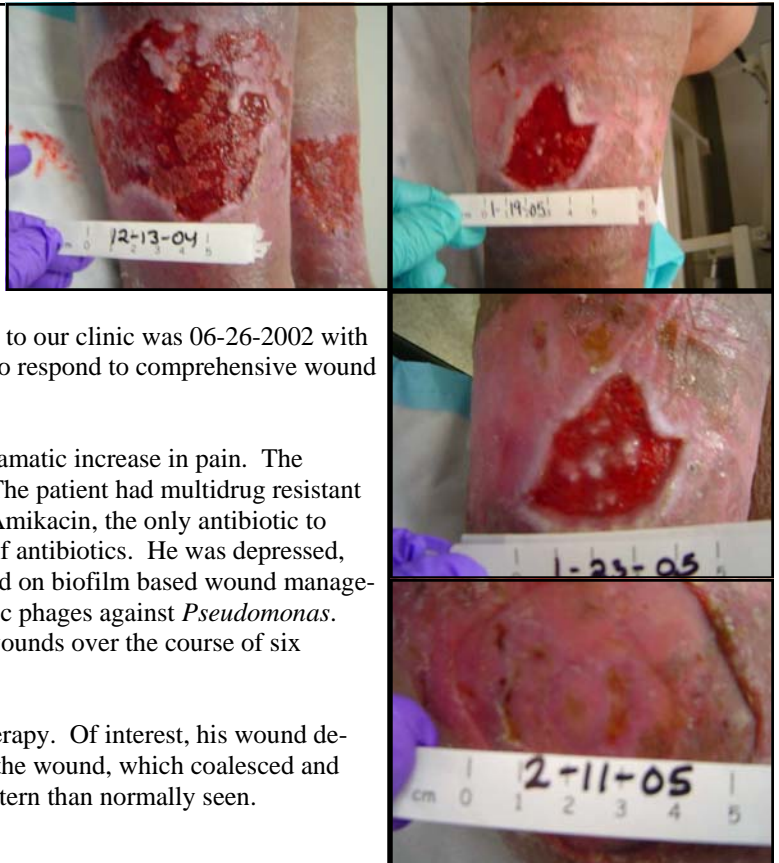
CASE HISTORY:

NAME: R.B.
ACCT: 4146

The patient is a very pleasant 60-year-old white male with lymphedema in the bilateral lower extremities, uncontrolled noninsulin dependent diabetes mellitus and nonhealing wounds on his lower extremities for many years. The patient's first visit to our clinic was 06-26-2002 with a very painful highly exudative wound. He failed to respond to comprehensive wound management.

The patient was readmitted in May of 2004 with dramatic increase in pain. The wounds were much deeper and highly exudative. The patient had multidrug resistant *Pseudomonas* bacteria intermediately sensitive to Amikacin, the only antibiotic to which it showed. He received weeks and weeks of antibiotics. He was depressed, and ended up losing his job. The patient was started on biofilm based wound management along with bacteriophage therapy with specific phages against *Pseudomonas*. The patient showed dramatic improvement in his wounds over the course of six weeks.

Teaching Point: The patient responded to phage therapy. Of interest, his wound developed epithelial islands throughout the center of the wound, which coalesced and filled the wound in, which is a different healing pattern than normally seen.



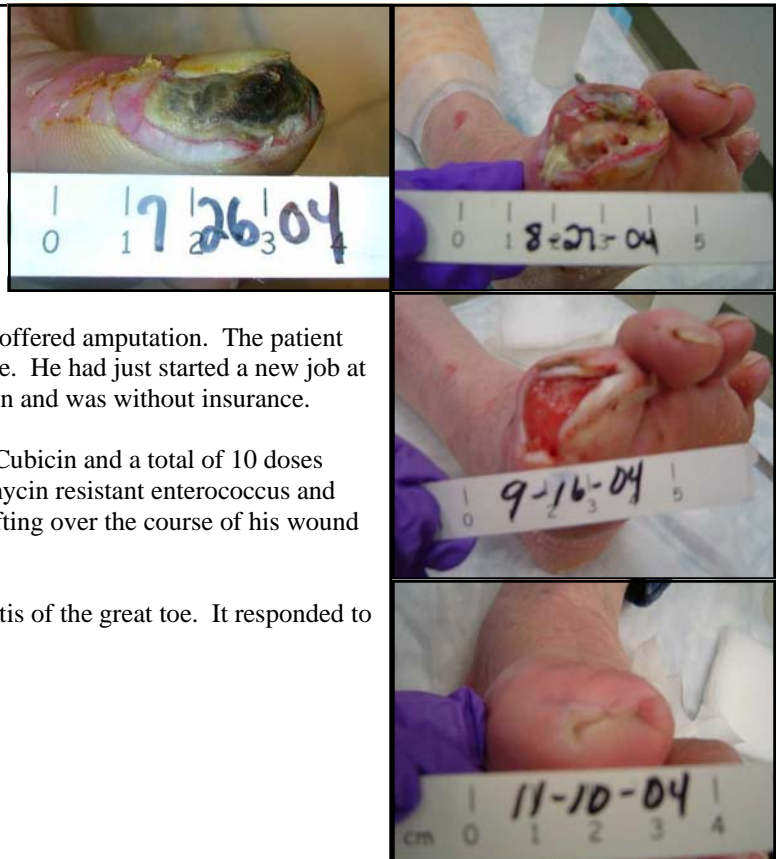
CASE HISTORY:

NAME: R.C.
ACCT: 9114

The patient is a very pleasant 48-year-old white male with severe diabetes mellitus. The patient has adequate circulation to his foot, but does have peripheral neuropathy. The patient developed gangrenous changes of his right great toe. He was offered amputation. The patient decided on conservative comprehensive wound care. He had just started a new job at the time the wound developed so he lost his position and was without insurance.

The patient was treated with a total of 10 doses of Cubicin and a total of 10 doses Maxipime. The patient was found to have Vancomycin resistant enterococcus and pseudomonas. The patient had six Dermagraft grafting over the course of his wound healing.

Teaching Point: The patient clearly had osteomyelitis of the great toe. It responded to minimal antibiotics and biofilm based wound care.



CASE HISTORY:

NAME: J.C.
ACCT: 8926

The patient is a very pleasant 60-year-old Latin American male who presented with a diabetic foot ulcer of the left great toe. He is divorced and lives about 35 miles from Lubbock and depends on his adult children for transportation. The patient is an insulin dependent diabetic for a number of years. He is a right below knee amputee. He has pancreatitis and hepatitis C. He is malnourished. The patient does show adequate blood flow to the foot, but severe peripheral neuropathy. The patient's wound grew out Klebsiella and Staph Aureus initially and after his operation continued to grow out Klebsiella and Staph Aureus. The patient was treated with a total of 40 doses of Cubicin and 20 doses of Maxipime and Aztreonam.

The patient presented initially with progressive lesion of his left great toe. By the 4th week the patient extended into his forefoot and was recommended for a transmet amputation. Two weeks later the patient returned to the clinic. His wound was questionable. He had wound dehiscence about 3 weeks later. The patient was managed aggressively and was able to close his wound in 4 months.

Teaching Point: The patient underwent transmet amputation because of a progressive wound. This led to a bigger wound, which had bacteria identical to the preoperative wound. The transmet operation did not decrease his healing time and actually caused the loss of additional tissue. This raises the question of whether a biofilm based wound management strategy might salvage more overall tissue and therefore more function.



CASE HISTORY:

NAME: N.C.
ACCT: 8906

The patient is a very pleasant 61-year-old white female with no medical problems. The patient sustained a traumatic wound to her left lower leg. This was primarily closed and approximately 5 days later the distal portion of the wound began turning black. The patient was placed on oral Levaquin, and over the next week the distal portion of the wound necrosed very deeply into the tissue. Several cultures showed no growth and special anaerobic culture showed no growth. The patient's wound continued to worsen. Despite the culture findings Invanz 1 gram IV was used for a total of 14 days. The wound did appear to respond to this with decreased drainage, decreased pain and decreased inflammation. Standard biofilm based wound care was conducted and the patient was healed by Christmas.

Teaching Point: In a fairly young healthy patient with a progressive wound and negative culture results, anaerobes may play a part. With the absence of any other barriers of healing an undetected microbial pathogen may be playing a role in deterioration of the wound.



CASE HISTORY:

NAME: W.C.
ACCT: 4868

The patient is a very pleasant 36-year-old black male with the onset of a chronic wound on his left lower extremity in the early part of 2002. The patient was diagnosed with pyoderma gangrenosum and was treated with steroids and other immunosuppressives as well as antibiotics. The patient was seen at The Wound Care Center at the first part of 2002. His culture showed a multidrug resistant *Pseudomonas*. It was sensitive to Primaxin and Amikacin. A total of 48 doses of Primaxin and 40 doses of Amikacin were used. The patient received massive quantities of narcotics during this time due to the severe pain. He was non-compliant and used marijuana as well. The patient had biopsies taken on 2 different occasions by dermatology and the findings were consistent with pyoderma gangrenosum. The patient was treated with traditional wound care management, moist interactive wound care with topicals including antibiotic beads, Iodosorb, Hydrofera Blue, Acticoat and many other silver compounds. None of these seemed to move the patient's wound towards healing. The patient was tried on a host of other interventions including wet-to-dry dressings with Dakin's solution and with vinegar, which only served to increase his pain. The patient was tried on autologous platelet therapy, this failed. Finally, in the early part of 2004 the patient was tried on concurrent strategies including prolonged IV antibiotics, frequent management of the surface, Gentamicin drops to the wound bed, and daily coverage with Promogran and Acticoat, and the wound began to heal. The patient's final picture was taken 3 years and 2 months after the initial visit. Once the wound started healing, the patient's narcotic use dropped off dramatically.

Teaching Point: *Pseudomonas* can produce a very tenacious biofilm and an exaggerated immune response. Concurrent strategies targeting the biofilm seem to have the most success.



CASE HISTORY:

NAME: R.C.
ACCT: 10589

The patient is a 79-year-old Latin American male with a 20-year history of diabetes. She is a resident of a nursing home. The patient has coronary artery disease and congestive heart failure. The patient was found to have methicillin resistant *Staph Aureus* in the wound of the right great toe. The patient was started on Vancomycin on 3/4/05.

The patient had failed to respond to three months of conservative wound care and then had a resection of the right great toe. That wound site dehisced and worsened over about a 6 week period of time and the patient was referred to The Wound Care Center.

The patient was started on biofilm based wound care along with hyperbaric oxygen. The wound responded.

The wound healed in 5 weeks.

Teaching Point: Managing wound healing barriers such as hypoxia along with biofilm based wound care is important.



CASE HISTORY:

NAME: L.D.
ACCT: 7726

The patient is a very pleasant 52-year-old black male with a nonhealing transmet amputation. The patient is an insulin dependent diabetic. He had poor blood flow into the left foot. He has diabetic peripheral neuropathy.

The patient's wound dehiscd. Those sutures were removed and the wound was allowed to open. He had methicillin resistant *Staph Aureus*. The patient underwent a total of 45 days of Vancomycin.

The patient's wound stayed fairly clean, free of biofilm and went onto complete healing within 16 weeks.

Teaching Point: Surfaces favor biofilms. Getting the wound opened and the surfaces exposed decreases the time for wound healing. Also it allows the surface to remain free of biofilm.



CASE HISTORY:

NAME: L.D.
ACCT: 7951

The patient is a very pleasant 67-year-old insulin dependent diabetic. The patient has had previous CVA's. The patient's wound grew out methicillin resistant *Staph Aureus* along with *Klebsiella*, *Proteus* and *Group D. Enterococcus*. Most of the organisms were sensitive to Levaquin and the patient took Levaquin 750 mg. daily for 30 days.

The patient's wound was aggressively opened on the first session and the patient went on to complete healing in 11 weeks.

Teaching Point: Aggressive opening of tunneling and undermining is important to shift the advantage away from the biofilm to the host. This also allows for better management of surfaces.



CASE HISTORY:

NAME: C.D.
ACCT: 10788

The patient is a very pleasant 45-year-old female with a 35-year history of insulin dependent diabetes mellitus. She has had multiple wounds lasting for over a year at a time on her feet. The patient developed a right great toe wound three months prior to seeking help. The patient had multiple rounds of antibiotics and wound interventions, which failed to heal the wounds.

The patient was found to have coag negative staph on admission to The Wound Care Center. Vascular studies were good. Culture showed coag negative staph sensitive to Keflex.

The wound healed in 3-1/2 weeks.

Teaching Point: The patient showed much faster healing than she had in the past as well as the ability to heal this particular wound when biofilm based wound management was employed.



CASE HISTORY:

NAME: F.E.
ACCT: 5110

The patient is a very pleasant 43-year-old black female with multiple sclerosis and severe immobility issues. The patient developed a deep sacral decubitus ulcer, which penetrated the presacral fascia and exposed the sacrum and coccyx region. The patient had osteo and the bacteria cultured included *Group D Enterococcus*, methicillin resistant *Staph Aureus*, *Citrobacter* and multidrug resistant *Pseudomonas*. The patient was treated intermittently with Vancomycin, Aztreonam and Maxipime. The patient's treatment course took one year.

Teaching Point: At no time did anyone suggest amputation. It is interesting to note that for foot ulcers, especially in diabetics amputations are quickly relied upon to "solve the problem". However, patients with chronic wounds in other areas, which would be difficult for amputation, are never considered for such a radical management. The two main reasons given are that the patient will get septic and die or that the wound will trac and cause more extensive damage and result in poor outcome. In biofilm-based diseases, sepsis is extremely rare.



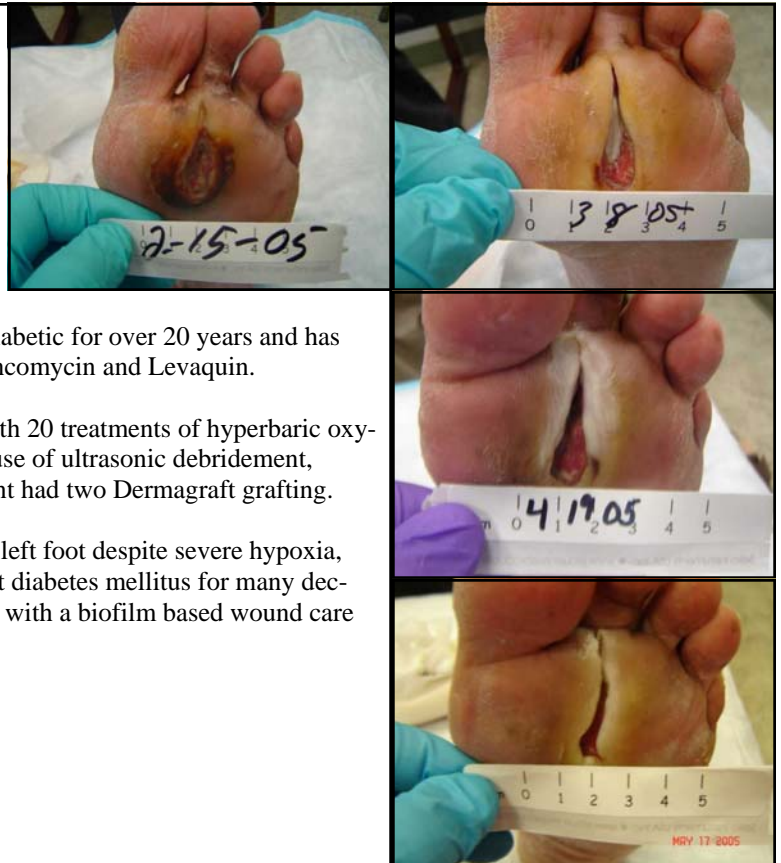
CASE HISTORY:

NAME: G.G.
ACCT: 6949

The patient is a very pleasant 63-year-old Latin American male with diabetic foot ulcer. The patient had an ulcer on the plantar surface of his foot, which penetrated through the tendon and to the bone. The patient has been an insulin dependent diabetic for over 20 years and has severe peripheral neuropathy. He is allergic to Vancomycin and Levaquin.

The patient underwent 8 doses of Cubicin along with 20 treatments of hyperbaric oxygen. Wound care included frequent debridement, use of ultrasonic debridement, Phages and antibacterial biofilm agents. The patient had two Dermagraft grafting.

Teaching Point: This extensive plantar ulcer of the left foot despite severe hypoxia, severe peripheral neuropathy and insulin dependent diabetes mellitus for many decades showed good clinical response in four months with a biofilm based wound care regimen.



CASE HISTORY:

NAME: M.G.
ACCT: 9263

The patient is a very pleasant 79-year-old Spanish-speaking only Latin American female with long-standing insulin dependent diabetes mellitus. The patient has peripheral neuropathy with poor perfusion of her right foot. The patient developed an abscess on the plantar aspect of the foot. This was opened and managed. The culture showed methicillin resistant *Staph Aureus*. The wound tracked toward the heel. Again, this was opened. All tunneling and undermining was exposed. Then a third time, the patient's wound tracked to the calcaneus and this was opened, exposing the surface of the calcaneus. The patient's wound went on to heal over the next 12 weeks.

Teaching Point: This case illustrates the importance of opening up all tracking and undermining to expose the surfaces of the wound. It sometimes requires persistence.



CASE HISTORY:

NAME: E.G.
ACCT: 10112

The patient is a very pleasant 34-year-old Latin American male with the acute onset of infected wound of his left chest. This came up rapidly over about a 10 day period. The patient does have contact with nursing home patients in his work. The wound was cultured and found to have methicillin resistant *Staph Aureus*, which may be community acquired. When the patient presented he was on Levaquin. The wound was draining, painful and progressive. The wound was debrided. A culture was taken and Phages applied. Cubicin 4mg/kg was started day 1 empirically. By day 5, the patient's wound showed dramatic decrease in edema, erythema, drainage and the pain was basically gone. The patient went on to heal up the wound in about 20 days.

Teaching Point: Multiple strategies including biofilm-effective anti-MRSA antibiotics, staph bacteriophage and a mixture of anti biofilm topicals were used on the wound and it showed rapid healing.



CASE HISTORY:

NAME: E.G.
ACCT: 10330

The patient is a very pleasant 87-year-old female with a nonhealing surgical wound of the abdomen. The patient had an extensive abdominal surgery. She spent two weeks on IV antibiotics in the hospital. The patient then was transferred to a long term acute care facility. The patient was started on comprehensive wound care management on 2/14/05 and healed three weeks later.

The wound healed in 3 weeks.

Teaching Point: A patient with a well-perfused wound can heal very rapidly with biofilm management.



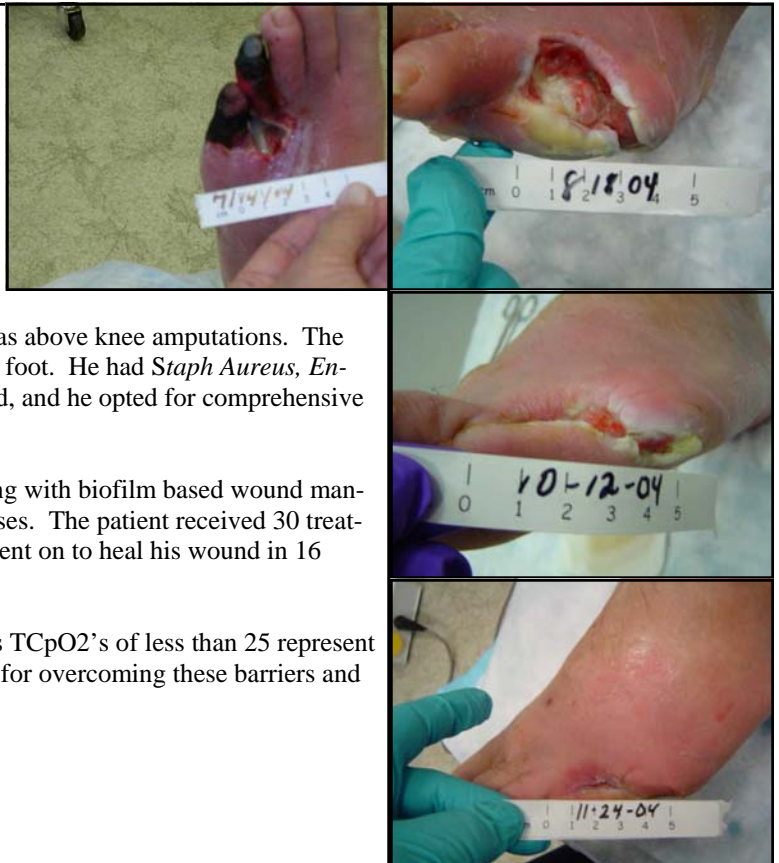
CASE HISTORY:

NAME: M.H.
ACCT: 7759

The patient is a very pleasant 57-year-old diabetic with peripheral neuropathy and severe peripheral vascular disease. The patient's TCpO₂ of the foot was 3 and the left calf was 17. The only surgical option offered to him by two surgical physicians was above knee amputations. The patient presented with diabetic foot ulcer of the left foot. He had *Staph Aureus*, *Enterobacter* and *Group D Enterococcus* in the wound, and he opted for comprehensive wound management.

The patient underwent aggressive debridement along with biofilm based wound management and Cubicin every day for a total of 30 doses. The patient received 30 treatments of hyperbaric oxygen as well. The patient went on to heal his wound in 16 weeks.

Teaching Point: Even though the literature suggests TCpO₂'s of less than 25 represent a non healable wound, there are multiple strategies for overcoming these barriers and to allow for wound healing.



CASE HISTORY:

NAME: W.I.
ACCT: 7314

The patient is a very pleasant 78-year-old white female with severe venous leg ulcer on the right lower extremity. The patient's ulcer basically enveloped the right lower leg covering about $\frac{3}{4}$ of the leg circumferentially. This was a very thick, tenacious biofilm. The patient's wound grew out a multidrug resistant *Pseudomonas*, *Group D Enterococcus*, methicillin resistant *Staph Epidermitis*, *Klebsiella*, and *Morganella*. The patient was treated with Zyvox, Maxipime and Aztreonam for a total of 42 days during her treatment course. In March anti pseudomonal and anti staphylococcus phages were applied and the biofilm has been much more manageable. The patient has had decreased pain and has stopped using narcotics. There is less drainage, and film is not redeveloping between dressing changes. There has been a dramatic improvement in the wound healing trajectory.

Teaching Point: The biofilm synergies and behaviors which contribute to the biofilm virulence are as important as host factors in healing wounds.



CASE HISTORY:

NAME: M.J.
ACCT: 8929

The patient is a very pleasant 23-year-old white male with T12 fracture March 1, 2004. The patient is an incomplete paraplegic and developed a severe decubitus ulcer on the heel. Initial evaluation showed extensive undermining. This was opened. The patient was cultured with *Proteus* and *Group D Enterococcus*. It was sensitive to Augmentin. Although the patient's wound took seven months to heal, the patient was able to continue in school and do extensive traveling.

Teaching Point: Decubitus ulcers offer multiple surfaces that touch each other (coapt). This provides an advantage to the biofilm and makes decubitus ulcers difficult to heal.



CASE HISTORY:

NAME: M.J.
ACCT: 5899

The patient is a very pleasant 78-year-old Latin American female with venous leg ulcer on her right medial ankle. The patient had the wound for over three years prior to our treatment in January of 2003. The wound showed *Pseudomonas*. There was good arterial circulation. The patient was treated intermittently with Primaxin and aggressive wound care. It was not until the middle of 2004 when anti biofilm techniques began to be used that the patient started responding to treatment.

Teaching Point: The patient showed good progression to wound closure from the middle of 2004 to January of 2005 when anti biofilm management was employed.

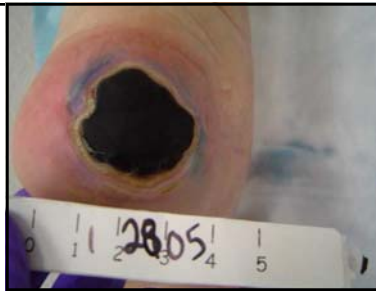


CASE HISTORY:

NAME: M.J.
ACCT: 8929

The patient is a very pleasant 23-year-old white male with T12 fracture March 1, 2004. The patient is an incomplete paraplegic and developed a severe decubitus ulcer on the coccyx region. Initial evaluation showed extensive undermining. This was opened. The patient was cultured with *Proteus* and *Group D Enterococcus*. It was sensitive to Augmentin. Although the patient's wound took seven months to heal, the patient was able to continue in school and do extensive traveling.

Teaching Point: Decubitus ulcers offer multiple surfaces that touch each other (coapt). This provides an advantage to the biofilm and makes decubitus ulcers difficult to heal.



CASE HISTORY:

NAME: D.L.
ACCT: 10378

The patient is a very pleasant 53-year-old Latin American male with a longstanding history of diabetes mellitus on dialysis. The patient has diabetic peripheral neuropathy involving the foot. The patient presented with gangrenous changes to his right foot. TCOMS showed a TCpO₂ of 5 at the right foot and 10 at the right calf. The left leg showed good perfusion and oxygenation. The patient was cultured out to have *Group D Enterococci* and multidrug resistant *Pseudomonas* in the right foot. The patient underwent aggressive debridement and biofilm management of his wound.

Teaching Point: The patient responded rapidly to biofilm based wound management.



CASE HISTORY:

NAME: A.M.
ACCT: 1074

The patient is a very pleasant 53-year-old Latin American male with severe insulin dependent diabetes mellitus for over 20 years. The patient previously underwent a right below the knee amputation. The patient presented with a gangrenous left great toe. This cultured *Pseudomonas* and *Enterococcus*. The TCOM measurement showed TCpO₂ of 2 in the foot and 12 at the BK level. The patient had been forcefully offered a right above knee amputation and preferred to attempt wound healing.

Teaching Point: Even the most desperate wounds require a trial of therapy to prevent amputation.



CASE HISTORY:

NAME: K.M.
ACCT: 2525

The patient is a very pleasant 33-year-old white female paraplegic. The patient developed a deep stage IV decubitus ulcer on the left ischium. This cultured out *Enterococcus*, *Pseudomonas* and *Enterobacter*. The patient was treated without antibiotics. The patient had biofilm based wound care with debridements every two weeks along with application of anti biofilm agents. Although the patient remained up in her chair and active, she was able to heal her wound in six months and it has remained healed for over four months.

Teaching Point: For some large wounds, which will take a long time to heal, it is important to take the patient's function into account. Trial and error demonstrates that the pressure from her chair was not having a negative impact on the wound. Therefore, the patient was able to remain mobile.

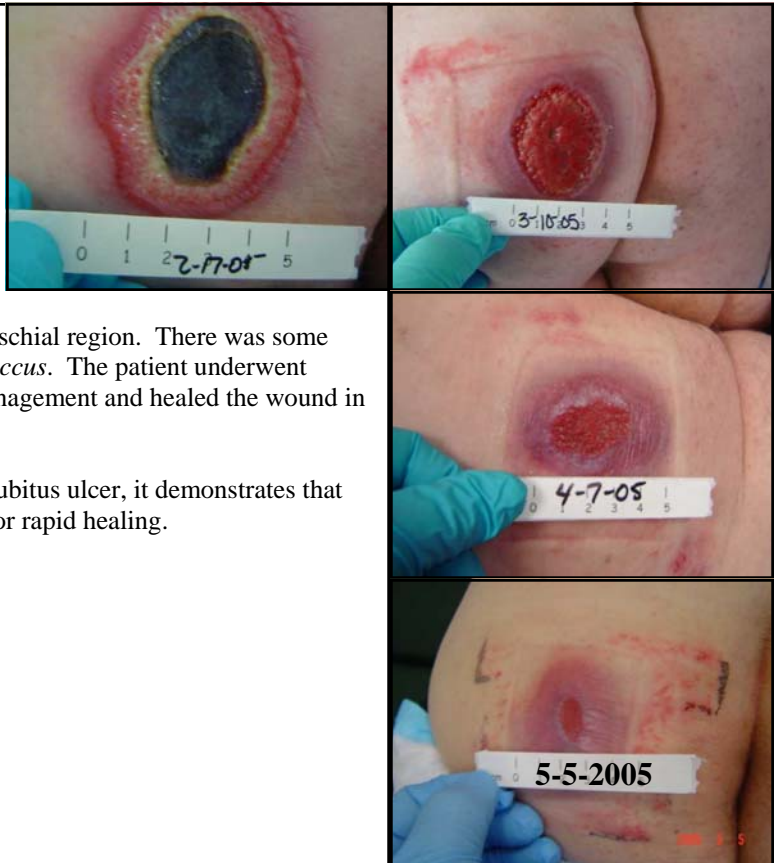


CASE HISTORY:

NAME: C.M.
ACCT: 10375

The patient is a very pleasant 72-year-old white male who suffered a traumatic wound to his left buttocks. The patient was in the hospital for surgical procedure and sustained a full thickness wound – basically a stage III decubitus ulcer – on the left ischial region. There was some drainage and pain and the culture showed *Enterococcus*. The patient underwent weekly debridement with biofilm based wound management and healed the wound in ten weeks.

Teaching Point: Although this was a shallower decubitus ulcer, it demonstrates that keeping the wound surface free of biofilm allows for rapid healing.

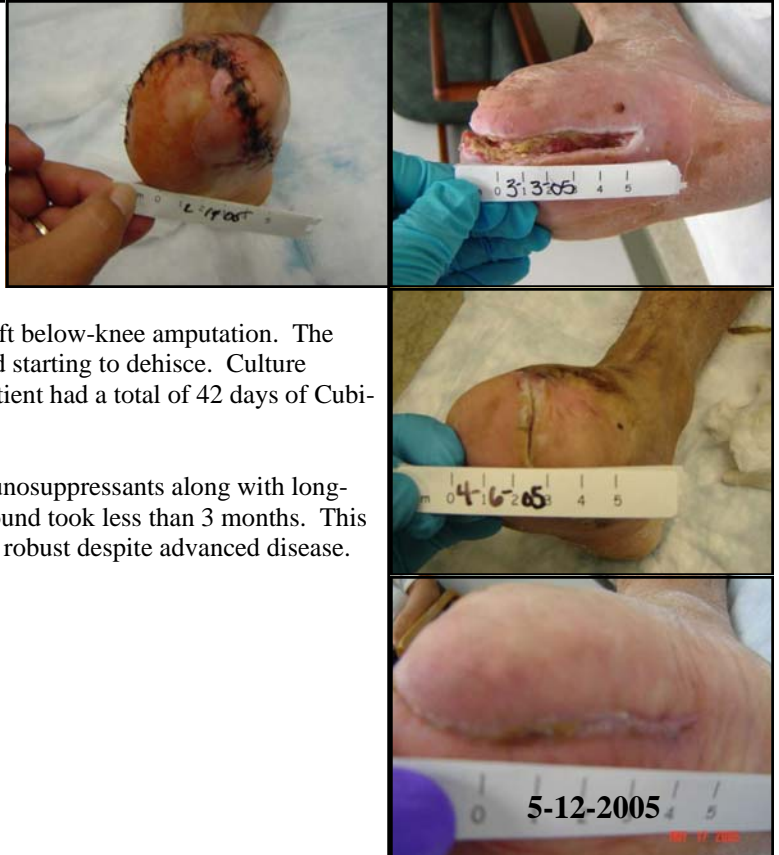


CASE HISTORY:

NAME: R.M.
ACCT: 3392

The patient is a very pleasant 48-year-old Latin American male. The patient has had previous renal transplant and is on immunosuppressant medications. He is an insulin dependent diabetic with severe peripheral neuropathy. He has a previous left below-knee amputation. The patient was presenting with the post surgical wound starting to dehisce. Culture showed methicillin resistant *Staph Aureus*. The patient had a total of 42 days of Cubicin and biofilm based wound management.

Teaching Point: The patient is on very potent immunosuppressants along with long-standing diabetes. Yet healing of this extensive wound took less than 3 months. This demonstrates that host-healing mechanisms remain robust despite advanced disease.



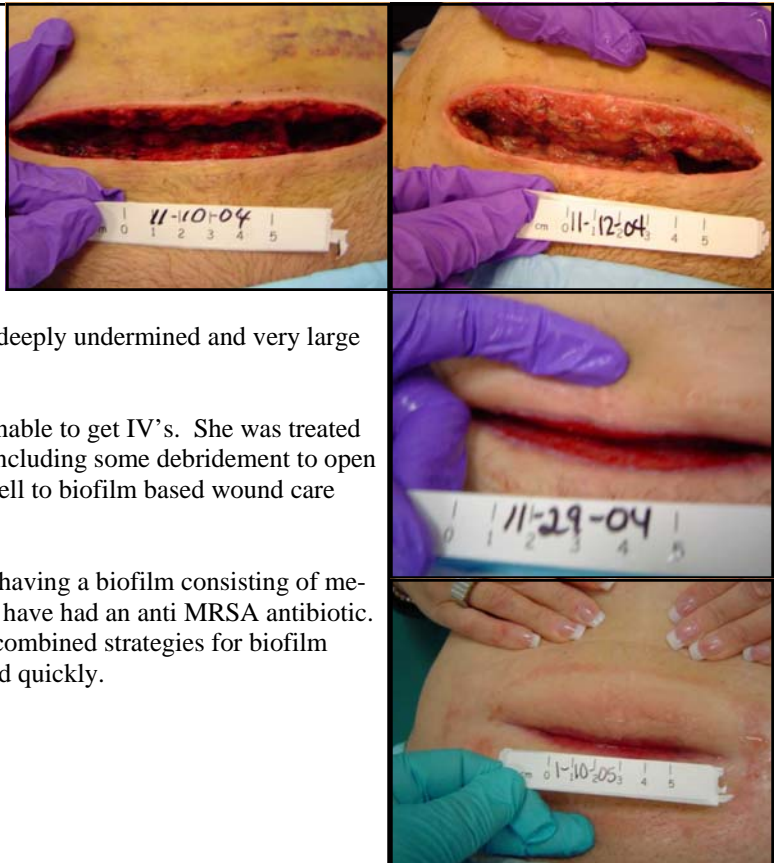
CASE HISTORY:

NAME: R.M.
ACCT: 9798

The patient is a very pleasant 45-year-old white female status post abdominal surgery 2 weeks prior to initial visit. The patient had methicillin resistant coag negative staph in the wound. There was quite a bit of drainage and pain and this was a deeply undermined and very large wound.

The patient was treated with Doxycycline. She is unable to get IV's. She was treated with weekly debridement to manage the surfaces, including some debridement to open up the undermining. The patient responded very well to biofilm based wound care and healed her large wound within 8 weeks.

Teaching Point: With this extensive postop wound having a biofilm consisting of methicillin resistant staph epi the patient really should have had an anti MRSA antibiotic. We were unable to accomplish this. And yet with combined strategies for biofilm management, the patient was able to heal her wound quickly.

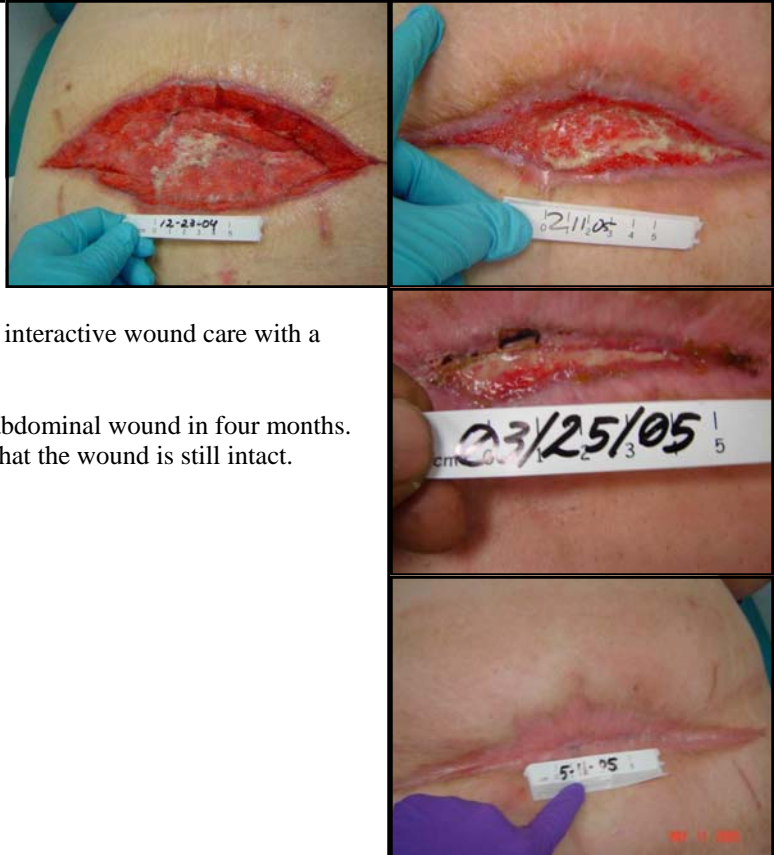


CASE HISTORY:

NAME: R.M.
ACCT: 9972

The patient is a very pleasant 52-year-old insulin dependent diabetic with a nonhealing surgical wound of the abdomen. The patient had cultured positive for methicillin resistant *Staph Aureus* and underwent 10 doses of Cubicin. We pursued moist interactive wound care with a biofilm based wound management.

Teaching Point: The patient healed this enormous abdominal wound in four months. Follow up picture two months later in May shows that the wound is still intact.



CASE HISTORY:

NAME: G.P.
ACCT: 7474

The patient is a very pleasant 96-year-old white female with longstanding insulin dependent diabetes mellitus, peripheral neuropathy and moderate peripheral vascular disease. The patient presented with diabetic foot ulcer at the first metatarsal head. This has eroded through to the joint. No organisms were ever cultured from the wound. The patient was treated for 25 days with Invanz.

Teaching Point: The patient took over 9 months to heal the wound, which involved the joint. She had advanced age, significant medical problems and impaired circulation. It is important to manage all barriers at every visit to allow for wound healing.



CASE HISTORY:

NAME: S.P.
ACCT: 4920

The patient is a very pleasant 67-year-old white male with venous insufficiency in the right lower extremity. The patient has a right medial ankle ulcer, which has been present for almost two decades. The patient was found to have a TCpO₂ of 13 at the right foot. The wound was growing coag negative staph resistant to methicillin. The patient was treated with traditional wound care until the middle of 2004. A biofilm based wound management program showed good improvement of the wound.

Teaching Point: The patient's severe, prolonged chronic venous leg ulcer complicated by peripheral arterial disease only started healing when a focused biofilm management strategy was employed.

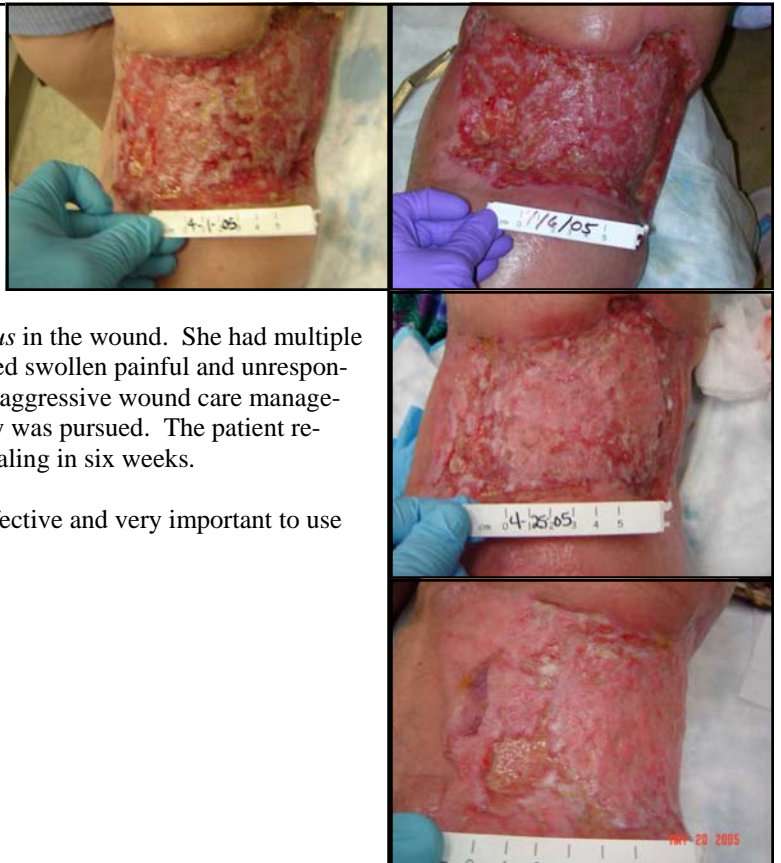


CASE HISTORY:

NAME: L.P.
ACCT: 10647

The patient is a very pleasant 54-year-old female status post traumatic wound to the left lower leg. The patient is a noninsulin dependent diabetic. She had a prolonged hospital stay post trauma and was found to have methicillin resistant *Staph Aureus* in the wound. She had multiple grafting and operative procedures. The leg remained swollen painful and unresponsive to IV antibiotics. The patient was referred for aggressive wound care management April 1st. Biofilm based management strategy was pursued. The patient responded very rapidly. She had almost complete healing in six weeks.

Teaching Point: A biofilm based strategy is still effective and very important to use with a drug resistant bacteria such as MRSA.



CASE HISTORY:

NAME: F.R.
ACCT: 9221

The patient is a very pleasant 87-year-old white female with a prolonged history of a venous leg ulcer on the right medial ankle. The patient had this for a number of years; it was painful with quite a bit of drainage. The patient showed adequate circulation and responded well to a biofilm based management program.

Teaching Point: Even with advanced age and prolonged chronic wound, biofilm based management shows rapid healing.



CASE HISTORY:

NAME: C.R.
ACCT: 10613

The patient is a very pleasant 78-year-old Latin American male status post CVA with a decubitus ulcer of the right heel. The decubitus ulcer has been present since hospitalization prior to Christmas and had been present for about four months. The patient demonstrated good oxygenation and perfusion. Culture showed *Staph Aureus* sensitive to Methicillin. The patient responded well to biofilm based wound management.

Teaching Point: Without other barriers to healing, wounds can heal in a very rapid manner with biofilm management strategy.



CASE HISTORY:

NAME: J.R.
ACCT: 9474

The patient is a very pleasant 58-year-old Latin American male with noninsulin dependent diabetes mellitus. The patient had acute arterial occlusion to his right foot and required a right below knee amputation. The patient got a postoperative wound infection with methicillin resistant *Staph Aureus*. The wound dehisced. There was exposed tibia. The patient received Vancomycin 1 gram daily for six weeks. During this time the patient was recommended to have an above knee amputation and he opted to go with conservative management. The patient has healed his wound in sixteen weeks with no recurrence for four weeks post healing.

Teaching Point: Definitive treatment such as below-knee or above-knee amputations fail to heal properly 30% of the time.



CASE HISTORY:

NAME: D.R.
ACCT: 9540

The patient is a very pleasant 71-year-old Latin American male with noninsulin dependent diabetes mellitus for 15 years. The patient had a diabetic foot ulcer with involved bone in the left great toe. The patient's vascular studies were adequate. The patient demonstrated methicillin resistant *Staph Aureus*. The patient was treated with Levaquin for 4 weeks.

Teaching Point: Even with osteomyelitis a biofilm based wound management can heal diabetic foot wounds.



CASE HISTORY:

NAME: R.S.
ACCT: 10733

The patient is a very pleasant 64-year-old white female who had a longstanding wound on the left lower extremity. The patient has rheumatoid arthritis and scleroderma and is on significant immunosuppressive medications. She has had a nonhealing wound of the left lower extremity for over two and a half years. The patient presented for aggressive wound care management.

The wound healed in 3-1/2 weeks.

Teaching Point: Biofilm based management strategies are very effective when patients are immunosuppressed. Fibroblasts and other host healing mechanisms remain effective.



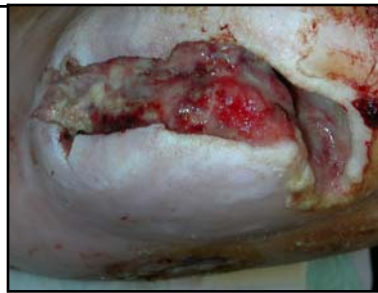
CASE HISTORY:

NAME: I.A.
ACCT: 6555

The patient is a very pleasant 44-year-old Latin American male longstanding insulin dependent diabetic. He has severe peripheral neuropathy with Charcot joints in both feet as well as significant lymphedema in the bilateral lower extremities. The patient developed severe diabetic foot ulcers in the bilateral feet. This penetrated to bone. The patient's blood sugar was out of control, arterial circulation to the foot was poor, and the patient was severely malnourished and continuing to walk on his feet. He was told he needed bilateral amputations. The patient was debrided aggressively, treated with anti biofilm agents and his barriers to healing were addressed. The patient suffers from diabetic retinopathy and underwent three different surgeries during this time as well.

The wound healed in 9 weeks.

Teaching Point: Although some patients have multiple barriers to prevent healing, if adequately addressed, healing can take place.



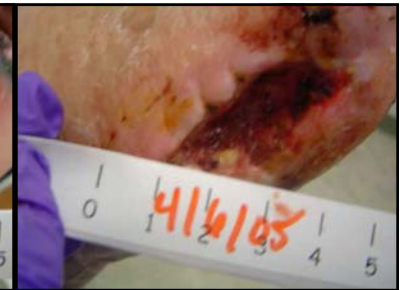
CASE HISTORY:

NAME: M.S.
ACCT: 10585

The patient is a very pleasant 84-year-old white female status post right foot surgery approximately two months prior to admission. The patient had fourth toe resection and a partial fifth ray resection. The wound dehiscence occurred approximately two weeks postop. It has failed to heal and continues to show progressive necrosis. The patient's vascular studies were good. The wound grew out *Strep Viridans*. The patient is a regent for George Washington University and opted to seek care in Lubbock.

The wound healed in 7 weeks.

Teaching Point: The patient had osteomyelitis and a deteriorating foot. She was offered an amputation but opted for a comprehensive wound management program. A biofilm based wound program achieved rapid healing.

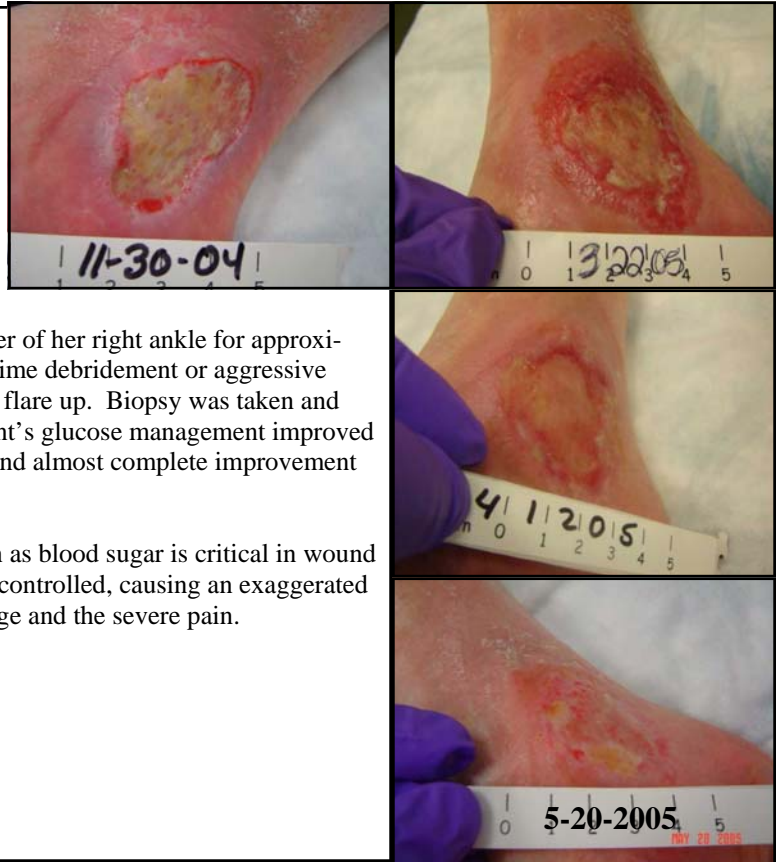


CASE HISTORY:

NAME: B.S.
ACCT: 7769

The patient is a very pleasant 74-year-old white female with insulin dependent diabetes mellitus. Her blood sugars have been erratic. She recently received an insulin pump and her blood sugars are much better controlled. The patient has had an ulcer of her right ankle for approximately three years. It would wax and wane. Any time debridement or aggressive management was attempted on the wound it would flare up. Biopsy was taken and pyoderma gangrenosum was diagnosed. The patient's glucose management improved in the first part of 2005. The patient made steady and almost complete improvement in the wound.

Teaching Point: Controlling systemic diseases such as blood sugar is critical in wound healing. Pyoderma appears to be biofilm that is uncontrolled, causing an exaggerated inflammatory response with undermining of the edge and the severe pain.



CASE HISTORY:

NAME: D.S.
ACCT: 10393

The patient is a very pleasant 72-year-old white male with gout. Approximately one year before the patient presented for wound care he received an injection in his right great toe.

This became infected and the patient subsequently underwent I&D. He had over nine months of conservative management of the foot and then was referred to The Wound Care Center. The patient showed good vascular studies and had no neurologic deficits. The patient grew out methicillin resistant staph epi. He received two weeks of Cubicin and aggressive biofilm based management. X-rays had shown bony destruction and involvement of the joint. The patient, however, went on to heal quickly with aggressive surface management and anti biofilm agents.

The wound healed in 8 weeks.

Teaching Point: Wound healing is possible even with severe disease such as gout and local osteomyelitis.



CASE HISTORY:

NAME: W.T.
ACCT: 2235

The patient is a very pleasant 78-year-old white male. The patient has severe peripheral vascular disease in the right lower extremity. The patient is a previous left below knee amputee two years ago.

The patient has longstanding insulin dependent diabetes mellitus. He has peripheral neuropathy. The patient's wound cultured methicillin resistant *Staph Aureus*, *Group D Enterococcus*, *Citrobacter*, *Enterobacter*, *Pseudomonas* and *E-Coli*. The patient had over 60 doses of Vancomycin and 20 doses of Cubicin during his treatment regimen.

The patient's wounds started with minor trauma to the right fifth toe. The gangrenous changes continued until it had crossed over the entire foot to the great toe causing autoamputation in the distal midfoot. The patient's wound continued to deteriorate until August of 2004. Multiple anti biofilm agents were used including Lactoferrin, Lactoferricin and high dose RNA-3 inhibitory peptide. There was a rapid change over the course of three weeks from a dark, progressively deteriorating wound to a red granular base which went on to heal over a six month period of time.

Teaching Point: The toxins released by the surface bacteria in the biofilm can cause extensive necrosis in an impaired host.



CASE HISTORY:

NAME: A.T.
ACCT: 10162

The patient is a very pleasant 66-year-old Latin American male with end stage renal disease, previous CVA, chronic anemia, CABG and who is on hemodialysis. The patient suffered several areas of intensely painful black eschar on his lower leg consistent with calciphylaxis. The patient had been managed supportively for six weeks prior to his initial visit. The scar was removed and the wound was treated in a biofilm based manner. The patient's right calf wound went onto heal in 10 weeks. No antibiotics were used.

Teaching Point: Removing eschar has been controversial. However, with tools to manage the biofilm that accumulates on the surface of the wound once the eschar is removed, there is no reason to allow this impediment to healing to remain on the wound bed.



CASE HISTORY:

NAME: R.T.
ACCT: 4763

The patient is a very pleasant 71-year-old black male with severe ulcer on the posterior left leg. The patient was living on the streets of New York when his family moved him to Lubbock. The patient had a polymicrobial biofilm including *Citrobacter*, *Acetobacter* and *Enterococcus*. This was a painful wound with quite a bit of drainage, and thick heavy biofilm would develop week to week. The patient had no major medical problems, but did have some mild peripheral neuropathy secondary to ethanol abuse. The patient continued to smoke and drink through the course of his treatment. The patient's wounds were debridement sporadically due to compliance. The patient had one course of Levaquin for 30 days.

Despite some compliance issues and continued ethanol and tobacco use, the patient's wound responded well. This illustrates a very thick, tenacious biofilm which would develop very rapidly. The patient returned within 24 hours one time because of dressing problems and literally overnight a thick biofilm had redeveloped on the surface of his wound. He eventually went from a wheelchair to walking with a cane.

Teaching Point: Biofilms develop a synergy among the organisms which make them up. This makes some biofilms much more difficult to deal with than others.



CASE HISTORY:

NAME: L.V.
ACCT: 454

The patient is a 90-year-old white male with a very long history of venous leg ulcer in his bilateral lower extremities. The patient has had open wounds on his lower legs for over four years. Initial culture showed *Pseudomonas* and methicillin resistant *Staph Aureus*. Vascular studies showed adequate arterial circulation. Over the course of two years the patient received over 60 doses of Amikacin for multidrug resistant *Pseudomonas* and 30 doses of Vancomycin for a methicillin resistant *Staph Aureus*. A trial of antibiotic beads was attempted for a three month period with no improvement. Once a comprehensive biofilm based management of the wound was employed, the patient was moved to complete healing.

Teaching Point: Multidrug resistant *Pseudomonas Aeruginosa* and methicillin resistant *Staph Aureus* create very difficult biofilms to manage. Multiple concomitant anti biofilm, anti pseudomonal, and anti staph strategies are required for healing.



CASE HISTORY:

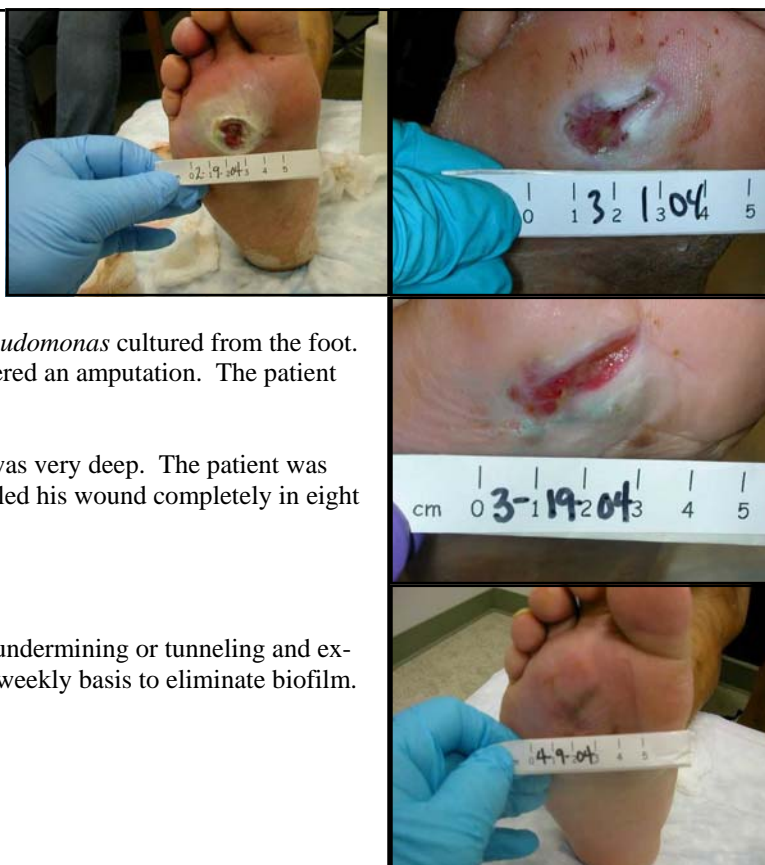
NAME: E.V.
ACCT: 8137

The patient is a very pleasant 39-year-old Latin American male with insulin dependent diabetes mellitus, mild peripheral neuropathy and adequate perfusion of his right foot. The patient sustained ulcer on the plantar surface of his foot. He had *Pseudomonas* cultured from the foot. He failed to heal over about six weeks and was offered an amputation. The patient sought comprehensive wound management.

The patient's wound was aggressively opened. It was very deep. The patient was placed on Gentamicin for 14 days. The patient healed his wound completely in eight weeks.

The wound healed in 8 weeks.

Teaching Point: It is very important to open up all undermining or tunneling and expose all surfaces so that they can be managed on a weekly basis to eliminate biofilm.



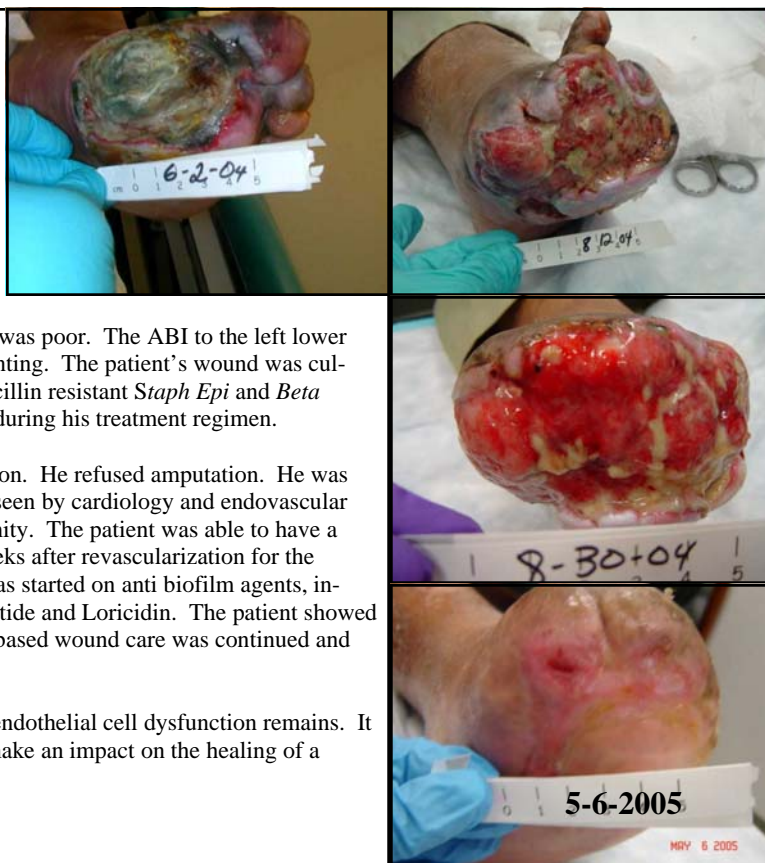
CASE HISTORY:

NAME: R.V.
ACCT: 8813

The patient is a very pleasant 74-year-old Latin American male with longstanding diabetes mellitus. The patient has peripheral neuropathy and significant peripheral vascular disease especially affecting the left lower extremity. The patient's TCPO₂ was 2. His toe perfusion pressure was poor (less than 10) and the waveform was poor. The ABI to the left lower extremity was .3. The patient was revascularized via stenting. The patient's wound was cultured. He cultured *E-coli*, *Proteus*, *Enterococcus*, methicillin resistant *Staph Epi* and *Beta Strep*. He received only one 14 day course of Levaquin during his treatment regimen.

The patient had severe deterioration of his wounds early on. He refused amputation. He was not a candidate for hyperbaric oxygen. The patient was seen by cardiology and endovascular revascularization was undertaken in the left lower extremity. The patient was able to have a pulse reestablished. Yet it still took approximately 6 weeks after revascularization for the wound to start improving. In July of 2004, the patient was started on anti biofilm agents, including Lactoferrin, Lactoferricin, RNA-3 inhibitory peptide and Loricidin. The patient showed excellent response to these anti biofilm agents. Biofilm based wound care was continued and the patient went on to complete healing by May of 2005.

Teaching Point: Even when wounds are revascularized, endothelial cell dysfunction remains. It may take an extended period of time for reperfusion to make an impact on the healing of a wound.

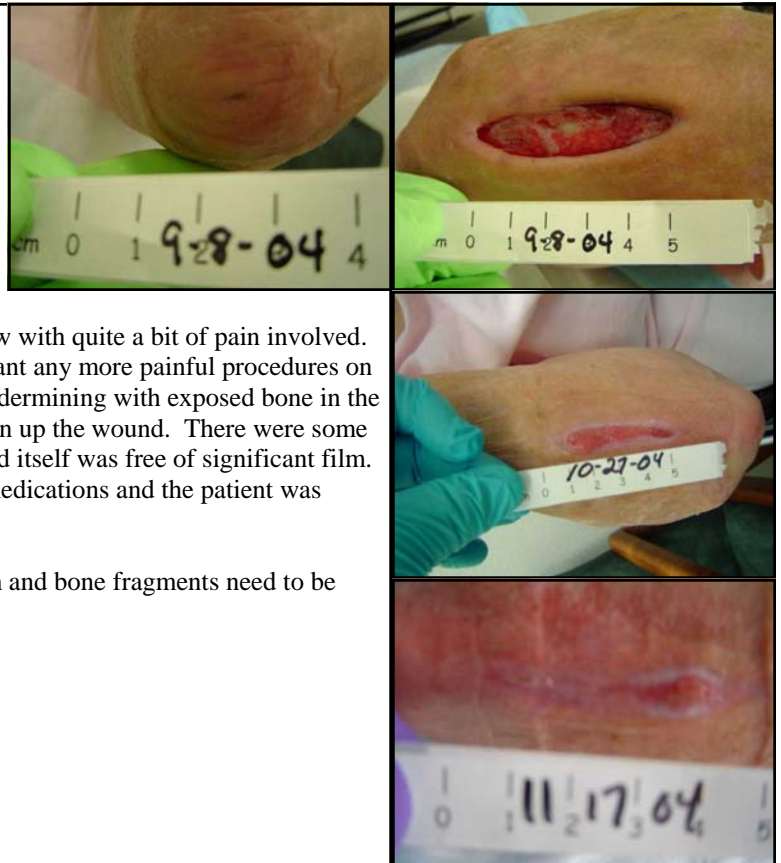


CASE HISTORY:

NAME: D.W.
ACCT: 9437

The patient is a very pleasant 58-year-old female with insulin dependent diabetes mellitus for a number of years. The patient underwent an elbow surgery approximately eight months prior to her initial visit. She continued to have a draining elbow with quite a bit of pain involved. The patient was on Coumadin and did not really want any more painful procedures on her arm. We probed the wound and found deep undermining with exposed bone in the elbow, and the patient consented to allow us to open up the wound. There were some bone fragments that were removed. The wound bed itself was free of significant film. Lab cultured *E-coli*, which was sensitive to most medications and the patient was placed on Levaquin.

Teaching Point: Foreign bodies such as sequestrum and bone fragments need to be removed to allow for wound healing.



CASE HISTORY:

NAME: S.W.
ACCT: 9337

The patient is a very pleasant 29-year-old white female with vasculitis and severe myositis. The patient had a biopsy obtained from the left thigh, which confirmed her myopathy. The patient's wound dehisced. We worked with the surgeon for over a month to try to get agreement to open the wound up. Once the wound was opened up it began to progress towards healing. The patient had severe medical problems throughout the course of healing. At no time did she go below 100 mg. of Prednisone daily. She was on a total of six different immunosuppressants. The patient lost the ability to stand, dress herself or raise her arms. For a 2-month period she required total assistance for eating.

The patient followed a biofilm based wound management program. She received a total of 12 doses of Primaxin and 10 doses of Invanz throughout her treatment. The patient received a total of 9 Apligraf and/or Dermagraft grafting over a 5-month period.

Teaching Point: Even though the patient was severely immunosuppressed and most of her mechanisms of healing were not available to her, with aggressive surface management of biofilm and use of bioengineered skin, the patient was able to close her wound.



CASE HISTORY:

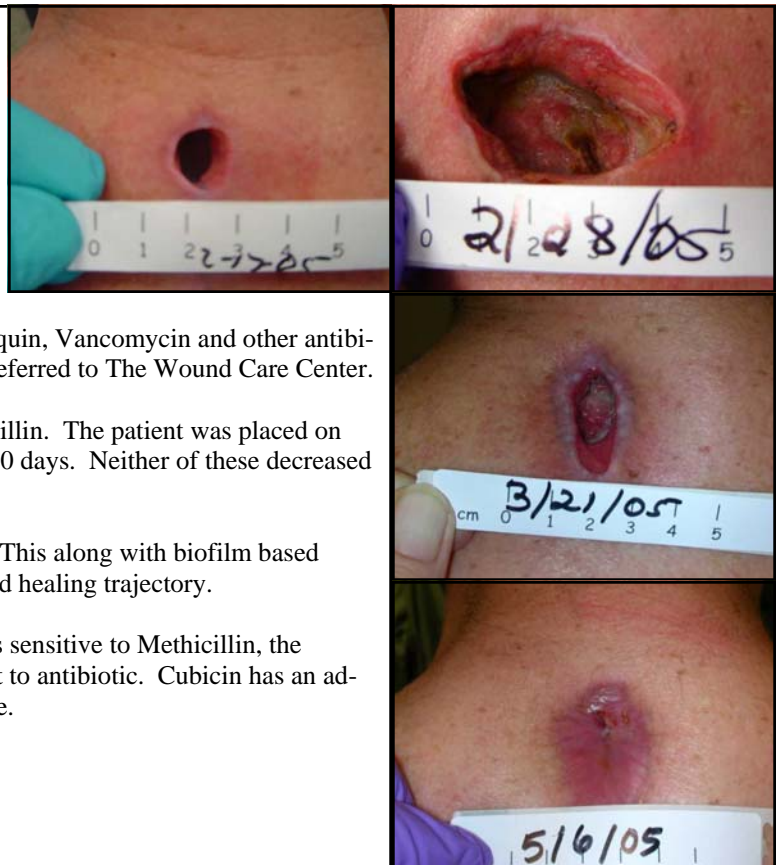
NAME: D.W.
ACCT: 10090

The patient is a very pleasant 47-year-old white male who is a Ph.D. candidate in molecular biology. The patient underwent neck surgery and for two months postoperatively had a draining, non-healing wound. The patient was treated with Levaquin, Vancomycin and other antibiotics. The wound failed to heal. The patient was referred to The Wound Care Center.

Culture showed a *Staph Aureus* sensitive to Methicillin. The patient was placed on Clindamycin for 10 days and then Augmentin for 10 days. Neither of these decreased the drainage or pain of the wound.

Cubicin 4mg/kg was given for a total of 14 doses. This along with biofilm based wound management changed the wound into a rapid healing trajectory.

Teaching Point: Even though the *Staph Aureus* was sensitive to Methicillin, the biofilm phenotype of *Staph Aureus* is very resistant to antibiotic. Cubicin has an advantage of being effective on the biofilm phenotype.



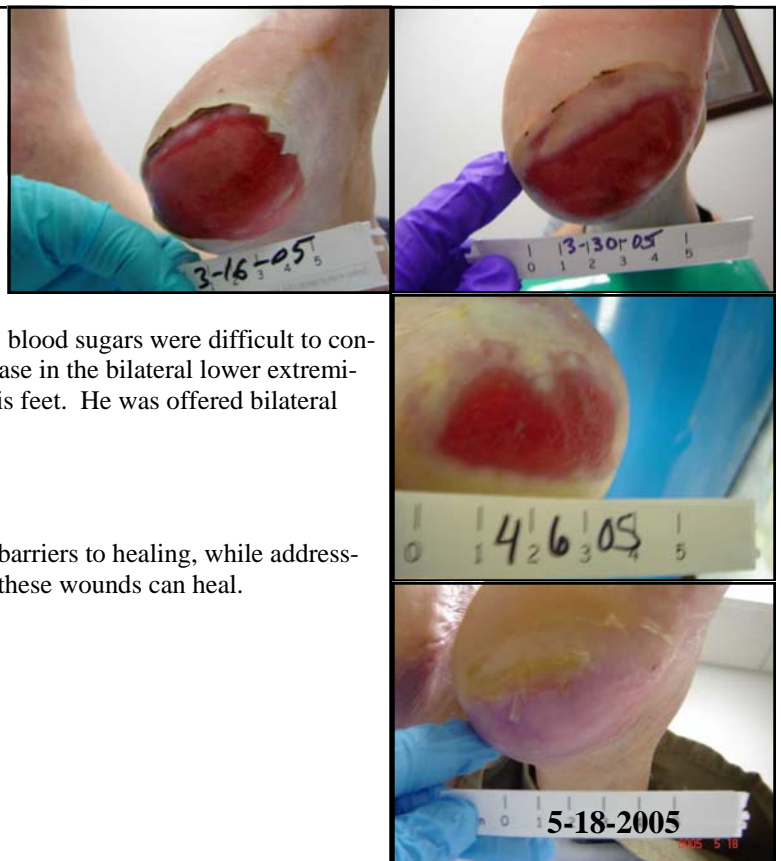
CASE HISTORY:

NAME: E.W.
ACCT: 10472

The patient is a very pleasant 76-year-old white male who presented with bilateral heel decubitus ulcers. The patient was very frail due to recent diagnosis of cancer and ongoing chemotherapy. The patient is an insulin dependent diabetic and his blood sugars were difficult to control. The patient had severe peripheral arterial disease in the bilateral lower extremities with poor oxygenation and poor perfusion of his feet. He was offered bilateral lower extremity amputations.

The wound healed in 7 weeks.

Teaching Point: Although the patient had multiple barriers to healing, while addressing each barrier, along with managing the biofilm, these wounds can heal.

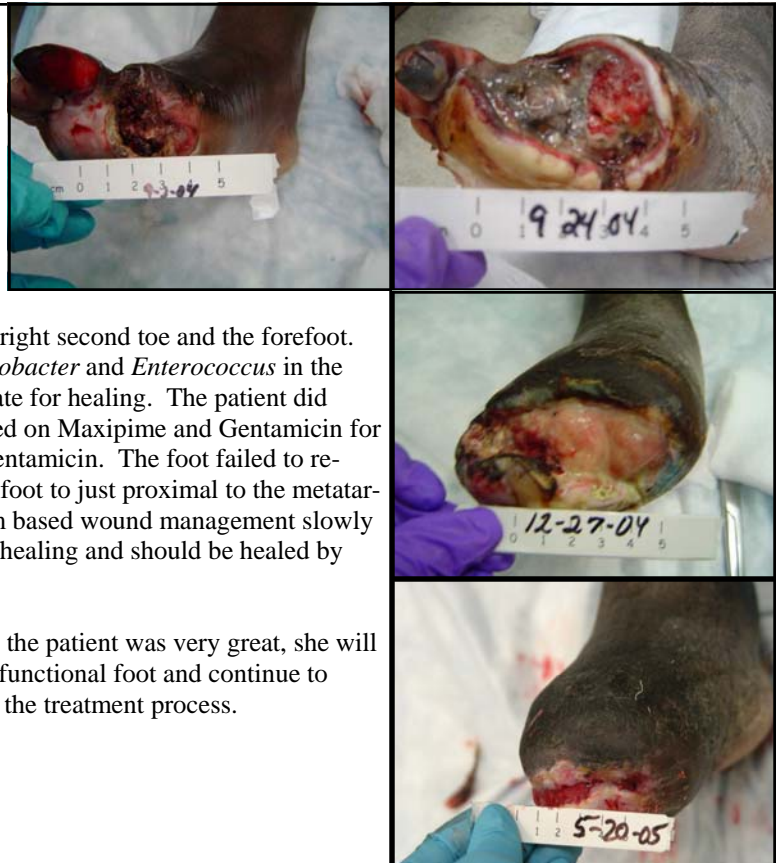


CASE HISTORY:

NAME: G.W.
ACCT: 9241

The patient is a very pleasant 61-year-old black female with longstanding insulin dependent diabetes on dialysis, severe hypertension and congestive heart failure. The patient presented with a very progressed necrotic infection in the right great toe, right second toe and the forefoot. Cultures showed *Pseudomonas*, *Citrobacter*, *Enterobacter* and *Enterococcus* in the wound. The patient's vascular studies were adequate for healing. The patient did show peripheral neuropathy. The patient was placed on Maxipime and Gentamicin for a total of 30 doses of Maxipime and 20 doses of Gentamicin. The foot failed to respond and initiated autoamputate of the toes of the foot to just proximal to the metatarsal level. Continued attention to detail with biofilm based wound management slowly brought the wound under control and the wound is healing and should be healed by the tenth month.

Teaching Point: Although the time commitment by the patient was very great, she will salvage her right lower extremity. She will have a functional foot and continue to walk. The patient has been ambulatory throughout the treatment process.



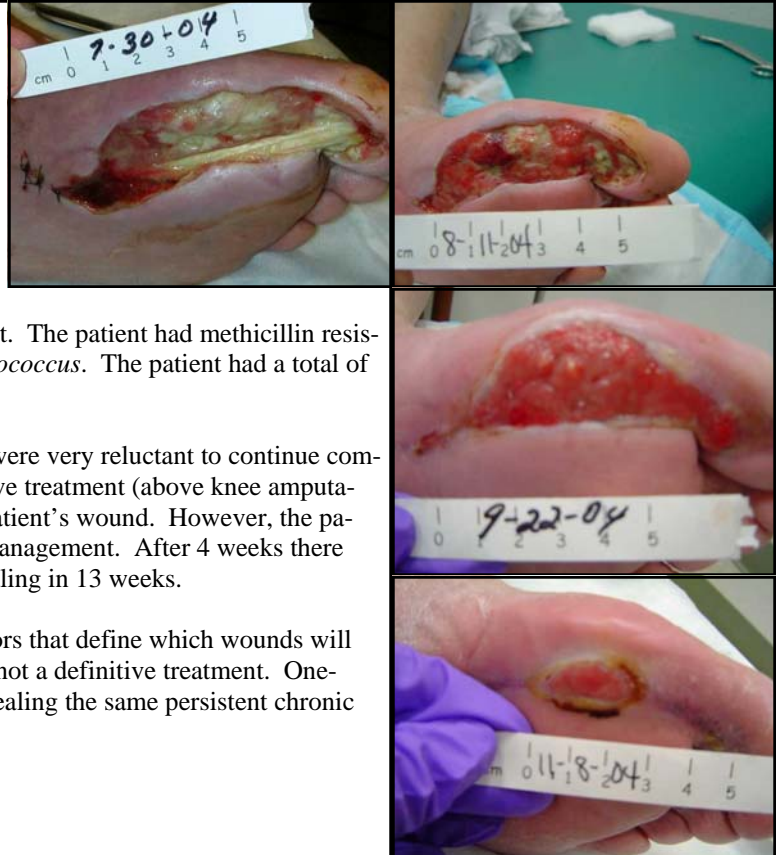
CASE HISTORY:

NAME: W.W.
ACCT: 9170

The patient is a very pleasant 54-year-old noninsulin dependent diabetic. The patient suffered extensive deterioration of the left great toe and first metatarsal head area. On the first visit the patient had exposed tendon and tracking down into his foot. The patient had methicillin resistant *Staph Aureus* and Vancomycin resistant *Enterococcus*. The patient had a total of 30 doses of Cubicin and 10 doses of Gentamicin.

The patient's primary care physician and surgeon were very reluctant to continue comprehensive wound management. They felt definitive treatment (above knee amputation) was the only "rational" way to manage this patient's wound. However, the patient reluctantly stuck with biofilm based wound management. After 4 weeks there was significant hope and the patient went on to healing in 13 weeks.

Teaching Point: There are no good clinical indicators that define which wounds will be healable and which ones won't. Amputation is not a definitive treatment. One-third of BK and AK sites dehisce and we are left healing the same persistent chronic wound at a more proximal area.



CASE HISTORY:

NAME: C.Y.
ACCT: 10076

The patient is a very pleasant 85-year-old Latin American male with multiple health problems. The patient is status post CVA and sustained a decubitus ulcer on the coccyx region. It is a stage IV decubitus ulcer with methicillin resistant *Staph Aureus* and *Group D Enterococcus* that has failed to heal in about 5 months. The patient was referred for aggressive wound care management. The patient was treated with Vancomycin and biofilm based wound care.

The wound healed in 15 weeks.

Teaching Point: This is a frail elderly patient with severe immobility and multiple problems in a nursing home. He was seen every two to four weeks yet was able to heal a large decubitus ulcer in 15 weeks (8 visits total) with a biofilm based approach.

